367.40292X00

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jukka HENRIKSSON

Application No. Not yet assigned

Filing Date: June 30, 2001

Title: DIVERSITY RECEIVER

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

June 30, 2001

Sir:

Prior to examination, please amend the above-identified application as follows.

IN THE SPECIFICATION

Page 1, line 5, delete "Background of the Invention" and replace with --Background--.

Page 2, delete paragraph beginning at line 15;

Please replace the paragraph beginning at page 2, line 18 with the following rewritten paragraph:

--Brief Summary

According to a first aspect, there is provided a receiver for receiving multi-carrier signal conveying data and reference signals and having first and second diversity branches each diversity branch being operable to extract the data and reference signals from the multi-carrier signal, thereby producing first and second sets of extracted data and reference signals,

comprising: a processor adapted to determine an estimation of the reliability of an extracted reference signal from each set of extracted reference signals; a combiner adapted to combine a data signal from the first and second set of extracted data signals in accordance with the determined estimation.--

Please replace the paragraph beginning at pages 2 and 3, line 29 with the following rewritten paragraph:

--According to a second aspect, there is provided a method of receiving a multi-carrier signal conveying data and reference signals at a receiver having first and second diversity branches each diversity branch being operable to extract the data and reference signals from the multi-carrier signal, thereby producing first and second sets of extracted data and reference signals, comprising: determining an estimation of the reliability of an extracted reference signal from each set of extracted reference signals; combing a data signal from the first and second set of extracted data signals in accordance with the determined estimation.--

Please replace the paragraph beginning at page 3, line 8 with the following rewritten paragraph:

--This application describes an improved way in which data signals from diversity branches may be combined. By filtering the extracted reference values, the effects of any erroneous reference values is reduced significantly. Additionally, combination of data signals is performed in a number of different ways depending on the estimated reliability of

each carrier. In this way, erroneous or disturbed carriers do not unduly affect an unaffected carrier. Such a system is particularly advantageous to mobile receivers where degradations caused by Doppler effects are common. The diversity receiver described in this application provides improved performance compared to diversity receivers of the prior art.--

Please replace the paragraph beginning at page 3, line 19 with the following rewritten paragraph:

--Brief Description of the Drawings

The invention will now be described, by way of example only, with reference to the accompanying diagrams, in which:

Figure 1 is a block diagram showing an example of a diversity receiver according to the prior art; and

Figure 2 is a block diagram of a diversity receiver according to a first embodiment of the invention.--

Page 3, line 26, delete "Detailed Description of the Invention" and replace with --Detailed Description--

Please replace the paragraph beginning at pages 4 and 5, line 26 with the following rewritten paragraph:

--Figure 2 is a block diagram of a diversity receiver 200 according to a first example embodiment of the invention. The diversity receiver 200 comprises two diversity branches

218 and 220. Since both of these diversity branches are equivalent, only the branch 218 will be described below. An OFDM signal 202, comprising pilot and data values is received by a fast Fourier transform (FFT) module 204, which de-maps the received pilot and data values to produce extracted pilot (or reference) and data values. A channel estimator 208 uses the extracted pilot values to provide an estimation of the channel distortion. A soft bit generator 206 generates soft bit data values from the extracted symbol data. Typically a four-bit soft data value is generated for each extracted data value. The channel estimation provided by a channel estimator 208 is fed to the soft bit generator 206 to correct for any channel distortion. This enables the soft bit generator 206 to provide more accurate soft data values.--

Please replace the paragraph beginning at page 6, line 6 with the following rewritten paragraph:

--In the filter 222, a credibility level cc_k is calculated for each carrier k having an amplitude c_k. Preferably, the credibility level is calculated as follows:

$cc_k = Median\ (c_{k-m}, c_{k-m+1},\ldots,c_k,\ldots,c_{k+m})$ Equation (1)

where c_{k-1} and c_{k+1} are the neighboring carriers. These are complex values containing both amplitude and phase information. Additionally, a number m of carriers above and below the present carrier are also taken. Preferably m is a small number between one and seven and is preferably an odd number to simplify the process of finding the median value. Alternatively, an even number could be used, although this slightly increases the complexity of the filter. The effect of the filtering is to smooth out any anomalous values.--

Please replace the paragraph beginning at pages 7 and 8, line 26 with the following rewritten paragraph:

--Alternatively, the filter 222 may calculate the mean value of a number of reference values. Furthermore, the number *m* of reference values used in the filter 222 for calculating the credibility factor may be varied dynamically in dependence on the characteristics of the channel conditions. Such characteristics can be obtained by the channel estimator 208. For example, in disturbed transmission channels, the number *m* of reference values used can be increased to spread the effect of any distorted reference values over a wide range. Alternatively, in a very clean channel, the number *m* of reference values can be reduced.--

Please replace the paragraph beginning at page 8, line 6 with the following rewritten paragraph:

--Those skilled in the art will also appreciate that other filtering operations could be performed by the filter 222, including both linear and non-linear filtering operations. The filter 222 could be implemented, for example, using a microprocessor, digital signal processor or other suitable processing means. Those skilled in the art will also appreciate that other weighting and combining schemes could be used, without detracting from the inventive concepts described herein. It will also be appreciated that, although the example embodiment of the invention is described with reference to OFDM and DVB-T technologies, it could equally be applied to any discrete multi-tone or multi-carrier signals. Additionally,

further diversity branches could be added and the results from each branch combined and filtered in accordance with the present invention as described above.--

IN THE CLAIMS

Please cancel claims 28 and 29 without prejudice or disclaimer.

Please amend claims 1, 5-8, 11-15, 19-22 and 25-27 as follows:

1. (Amended) A receiver for receiving a multi-carrier signal conveying data and reference signals and having first and second diversity branches, each diversity branch being operable to extract the data and reference signals from the multi-carrier signal, thereby producing first and second sets of extracted data and reference signals, comprising:

a processor adapted to determine an estimation of the reliability of an extracted reference signal from each set of extracted reference signals;

a combiner adapted to combine a data signal from the first and second set of extracted data signals in accordance with the determined estimation.

5. (Amended) A receiver according to claim 2, wherein the process of calculation determines the median of a set of extracted reference signals.

6. (Amended) A receiver according to claim 2, wherein the process of calculation determines the mean of a set of extracted reference signals.

7. (Amended) A receiver according to claim 1, wherein the combiner applies a weighting to each extracted data signal prior to combining.

8. (Amended) A receiver according to claim 2, wherein, the combiner combines the first and second set of extracted data signals in a first manner when the difference between the determined reliability of each set of reference signals is above a predetermined threshold, and for combining the first and second set of extracted data signals in a second manner when the determined reliability difference of each set of reference signals is below the predetermined threshold.

11. (Amended) A receiver according to claim 8, wherein the second manner of combining is by signal selection.

12. (Amended) A receiver according to claim 1, wherein the processor is a filter.

13. (Amended) A receiver according to claim 1, further comprising at least a third diversity branch.

14. (Amended) A receiver according to claim 1, wherein the receiver is adapted to receive orthogonal frequency division multiplex (OFDM) signals.

15. (Amended) A method of receiving multi-carrier signal conveying data and reference signals at a receiver having first and second diversity branches, each diversity branch being each operable to extract the data and reference signals from the multi-carrier

signal, thereby producing first and second sets of extracted data and reference signals, comprising:

determining an estimation of the reliability of an extracted reference signal from each set of extracted reference signals;

combining a data signal from the first and second set of extracted data signals in accordance with the determine estimation.

19. (Amended) A method according to claim 17, wherein the step of determining comprises determining the median of the reference signals.

20. (Amended) A method according to claim 17, wherein the step of determining comprises determining the mean of the reference signals.

21. (Amended) A method according to claim 15, further comprising applying a weighting to each extracted data signal prior to combining.

22. (Amended) A method according to claim 15, wherein the step of combining combines the first and second set of extracted data signals in a first manner when the difference between the determined reliability of each set of reference signals is above a predetermined threshold, and for combining the first and second set of extracted data signals in a second manner when the determined reliability difference of each set of reference signals is below the predetermined threshold.

25. (Amended) A method according to claim 22, wherein the second manner of combining performs a signal selection.

26. (Amended) A method to claim 15, wherein the step of determining further comprises filtering the extracted reference signals.

27. (Amended) A method according to claim 15, for receiving orthogonal frequency division multiplex (OFDM) signals.

IN THE ABSTRACT

A diversity receiver comprises two or more diversity branches. Each diversity branch is operable to extract sets of data and reference signals from received carriers. An estimate of the reliability of the extracted reference signals is determined and the data signals are then combined.

REMARKS

Attached here is a marked-up version of the changes made to the specification and claims by the current preliminary amendment. The attached page is captioned "**Version with marking to show changes made.**

Please charge any shortage in fees due in connection with the filing of this paper, or credit any overpayment of fees, to the deposit account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (367.40292X00).

Respectfully submitted,

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Attachment

VERSION WITH MARKINGS TO SHOW CHANGES MAKE

In the specification

Subtitle beginning at line 5 of page 1 has been amended to read as follows:

Background ~~of the invention~~

Paragraph beginning at line 15 of page 2 has been amended as follows:

~~Accordingly, one aim of the present invention is to provide an improved diversity receiver.~~

Brief Summary ~~of the invention~~

According to a first aspect, ~~of the present invention~~ there is provided a receiver for receiving multi-carrier signal conveying data and reference signals and having ~~a~~ first and second diversity branches each diversity branch being operable to extract the data and reference signals from the multi-carrier signal, thereby producing ~~a~~ first and second sets of extracted data and reference signals, comprising: a processor ~~for determining~~ adapted to determine an estimation of the reliability of an extracted reference signal from each set of extracted reference signals; a combiner ~~for combining~~ adapted to combine a data signal from the first and second set of extracted data signals in accordance with the determined estimation.--

Paragraph beginning at pages 2 and 3, line 29 have been amended as follows:

According to a second aspect, ~~of the present invention~~ there is provided a method of receiving a multi-carrier signal conveying data and reference signals at a receiver having ~~a~~ first and second diversity branches each diversity branch being operable to extract the data

and reference signals from the multi-carrier signal, thereby producing a first and second sets of extracted data and reference signals, comprising: determining an estimation of the reliability of an extracted reference signal from each set of extracted reference signals; combing a data signal from the first and second set of extracted data signals in accordance with the determined estimation.

Paragraph beginning at page 3, line 8 has been amended as follows:

~~The present invention advantageously provides~~ This application describes an improved way in which data signals from diversity branches may be combined. By filtering the extracted reference values, the effects of any erroneous reference values is reduced significantly. Additionally, combination of data signals is performed in a number of different ways depending on the estimated reliability of each carrier. In this way, erroneous or disturbed carriers do not unduly affect an unaffected carrier. Such a system is particularly advantageous to mobile receivers where degradations caused by Doppler effects are common. The ~~present invention~~ diversity receiver described in this application provides improved performance compared to diversity receivers of the prior art.

Paragraph beginning at page 3, line 19 has been amended as follows:

Brief Description of the Drawings

The invention will now be described, by way of example only, with reference to the accompanying diagrams, in which:

Figure 1 is a block diagram showing an example of a diversity receiver according to the prior art; and

Figure 2 is a block diagram of a diversity receiver according to a first embodiment ~~according to~~ of the present invention.

Subtitle beginning at page 3, line 26, has been amended as follows:

Detailed Description ~~of the Invention~~

Paragraph beginning at pages 4 and 5, line 26 has been amended as follows:

Figure 2 is a block diagram of a diversity receiver 200 according to a first example embodiment ~~according to~~ of the ~~present~~ invention. The diversity receiver 200 comprises two diversity branches 218 and 220. Since both of these diversity branches are equivalent, only the branch 218 will be described below. An OFDM signal 202, comprising pilot and data values is received by a fast Fourier transform (FFT) module 204, which de-maps the received pilot and data values to produce extracted pilot (or reference) and data values. A channel estimator 208 uses the extracted pilot values to provide an estimation of the channel distortion. A soft bit generator 206 generates soft bit data values from the extracted symbol data. Typically a four-bit soft data value is generated for each extracted data value. The channel estimation provided by a channel estimator 208 is fed to the soft bit generator 206 to correct for any channel distortion. This enables the soft bit generator 206 to provide more accurate soft data values.

Paragraph beginning at page 6, line 6 has been amended as follows:

In the filter 222, a credibility level cc_k is calculated for each carrier k having an amplitude c_k. ~~In a preferred embodiment~~ Preferably, the credibility level is calculated as follows:

$$cc_k = Median\ (c_{k-m}, c_{k-m+1},\ldots,c_k,\ldots,c_{k+m}) \qquad \text{Equation (1)}$$

where c_{k-1} and c_{k+1} are the neighboring carriers. These are complex values containing both amplitude and phase information. Additionally, a number m of carriers above and below the present carrier are also taken. Preferably m is a small number between one and seven and is preferably an odd number to simplify the process of finding the median value. Alternatively, an even number could be used, although this slightly increases the complexity of the filter. The effect of the filtering is to smooth out any anomalous values.

Paragraph beginning at pages 7 and 8, line 26 was amended as follows:

~~In an alternative~~ Alternatively, the filter 222 may calculate~~s~~ the mean value of a number of reference values. ~~In yet a further embodiment~~ Furthermore, the number m of reference values used in the filter 222 for calculating the credibility ~~is~~ factor may be varied dynamically in dependence on the characteristics of the channel conditions. Such characteristics can be obtained by the channel estimator 208. For example, in disturbed transmission channels, the number m of reference values used can be increased to spread the

effect of any distorted reference values over a wide range. Alternatively, in a very clean channel, the number m of reference values can be reduced.

Paragraph beginning at page 8, line 6 has been amended as follows:

Those skilled in the art will also appreciate that other filtering operations could be performed by the filter 222, including both linear and non-linear filtering operations. The filter 222 could be implemented, for example, using a microprocessor, digital signal processor or other suitable processing means. Those skilled in the art will also appreciate that other weighting and combining schemes could be used, without detracting from the inventive concepts described herein. It will also be appreciated that, although the ~~present~~ example embodiment of the invention is described with reference to OFDM and DVB-T technologies, ~~the present invention~~ it could equally be applied to any discrete multi-tone or multi-carrier signals. Additionally, further diversity branches could be added and the results from each branch combined and filtered in accordance with the present invention as described above.

IN THE CLAIMS

Claims 28 and 29 have been canceled.

Claims 1, 5-8, 11-15, 19-22, 26 and 27 have been amended as follows:

1. (Amended) A receiver for receiving a multi-carrier signal conveying data and reference signals and having ~~a~~ first and second diversity branches, each diversity branch being operable to extract the data and reference signals from the multi-carrier signal, thereby producing ~~a~~ first and second sets of extracted data and reference signals, comprising:

a processor adapted to determine an estimation of the reliability of an extracted reference signal from each set of extracted reference signals;

a combiner ~~for determining~~ adapted to combine a data signal from the first and second set of extracted data signals in accordance with the determined estimation.

5. (Amended) A receiver according to claim 2, ~~3 or 4~~ wherein the process of calculation determines the median of ~~the~~ a set of extracted reference signals.

6. (Amended) A receiver according to claim 2, ~~3 or 4~~ wherein the process of calculation determines the mean of ~~the~~ a set of extracted reference signals.

7. (Amended) A receiver according to ~~any preceding~~ claim 1, wherein the combiner applies a weighting to each extracted data signal prior to combining.

8. (Amended) A receiver according to ~~any preceding~~ claim 2, wherein, the combiner combines the first and second set of extracted data signals in a first manner when the difference between the determined reliability of each set of reference signals is above a predetermined threshold, and for combining the first and second set of extracted data signals in a second manner when the determined reliability difference of each set of reference signals is below the predetermined threshold.

11. (Amended) A receiver according to claim 8, ~~9 or 10~~ wherein the second manner of combining is by signal selection.

12. (Amended) A receiver according to ~~any of claims~~ claim 1 ~~to 11~~, wherein the processor is a filter.

13. (Amended) A receiver according to ~~any preceding~~ claim 1, further comprising at least ~~three~~ a third diversity ~~branches~~ branch.

14. (Amended) A receiver according to ~~any preceding~~ claim 1, wherein the receiver is adapted to receive orthogonal frequency division multiplex (OFDM) signals.

15. (Amended) A method of receiving multi-carrier signal conveying data and reference signals at a receiver having ~~a~~ first and second diversity branches, each diversity branch being each operable to extract the data and reference signals from the multi-carrier

signal, thereby producing ~~a~~ first and second sets of extracted data and reference signals, comprising:

determining an estimation of the reliability of an extracted reference signal from each set of extracted reference signals;

combining a data signal from the first and second set of extracted data signals in accordance with the determine estimation.

19. (Amended) A method according to claim 17 ~~or 18~~, wherein the step of determining comprises determining the median of the reference signals.

20. (Amended) A method according to claim 17 ~~or 18~~, wherein the step of determining comprises determining the mean of the reference signals.

21. (Amended) A method according to ~~any of claims~~ claim 15 ~~to 20~~, further comprising applying a weighting to each extracted data signal prior to combining.

22. (Amended) A method according to ~~any of claims~~ claim 15 ~~to 21~~, wherein the step of combining combines the first and second set of extracted data signals in a first manner when the difference between the determined reliability of each set of reference signals is above a predetermined threshold, and for combining the first and second set of extracted data signals in a second manner when the determined reliability difference of each set of reference signals is below the predetermined threshold.

25. (Amended) A method according to claim 22, ~~23 or 24~~ wherein the second manner of combining performs a signal selection.

26. (Amended) A method to ~~any of claims~~ claim 15 ~~to 25~~, wherein the step of determining further comprises filtering the extracted reference signals.

27. (Amended) A method according to ~~any of claims~~ claim 15 ~~to 26~~, for receiving orthogonal frequency division multiplex (OFDM) signals.

IN THE ABSTRACT

~~The present invention relates to receivers, and, more particularly, to improved diversity receivers.~~

~~In some environments, such as those subject to mulipath reflection or shadowing, some carriers may be received with low power. In these cases, diversity receivers may provide an improvement or around 3dB to 6dB, the latter figure referring to cases where the communication channel is under sever mutipath fading and in mobile reception.~~ A diversity receiver ~~effectively~~ comprises two or more ~~separate receivers or~~ diversity branches. Each diversity branch is operable to extract sets of data and reference signals from received carriers. An estimate of the reliability of the extracted reference signals is determined and the data signals are then combined.

~~Figure 2~~